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Production of high value lactic acid based, bio-chemicals using low OpEx end-to-end solution™

Retrofit/Upgrade existing fermentation sites

Former Brewery
100,000 Tonnes

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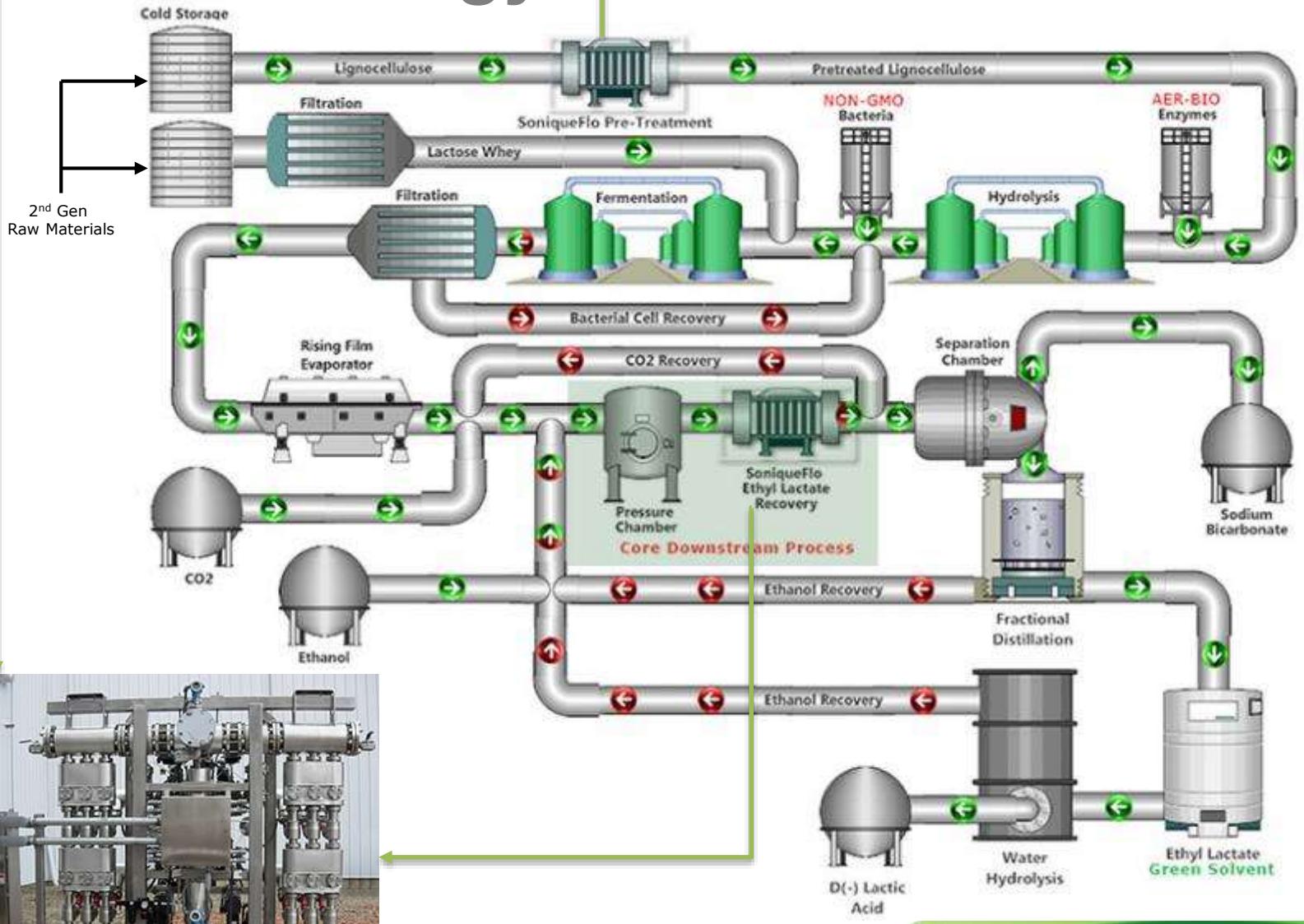
Technology / Process Overview



Nameplate Capacity: 100,000MT

Cellulac Production Facility

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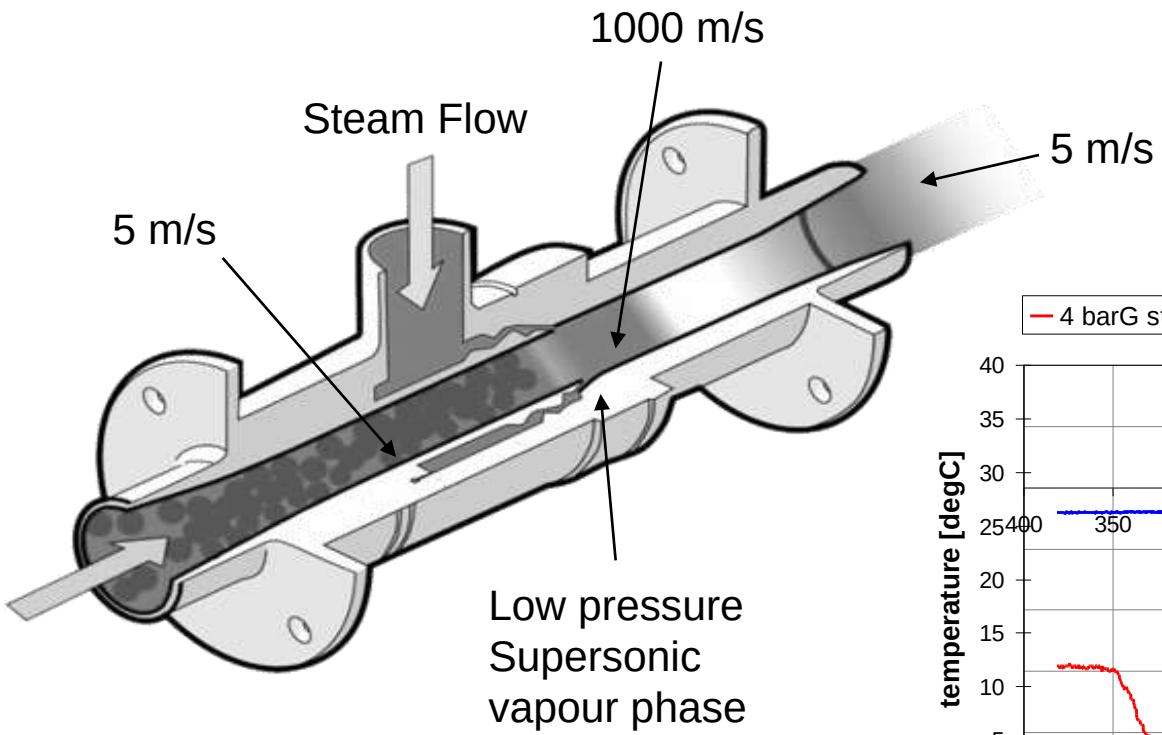
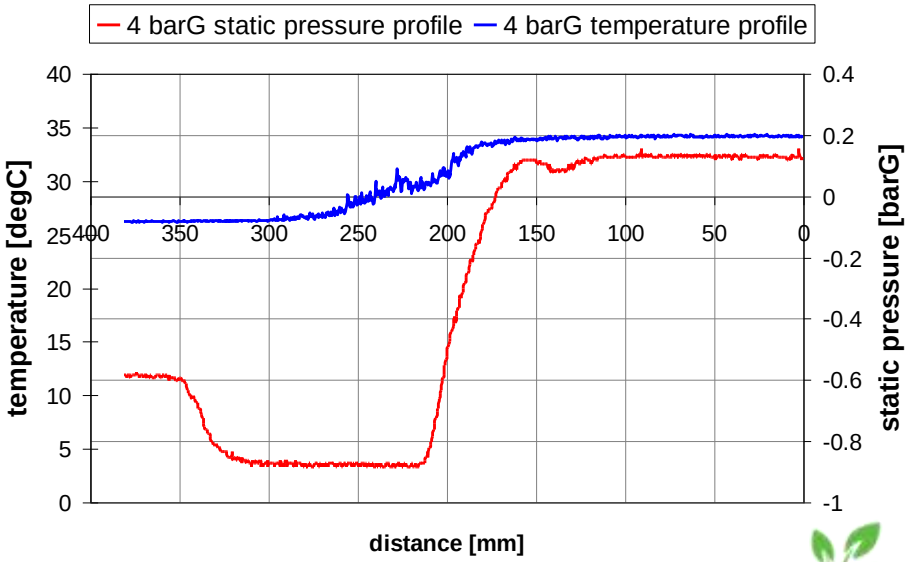
Agenda

1	**Core Technology**
2	Food and Beverage
3	Brewing
4	Industrial Mixing
5	BioEnergy
6	Waste Water
7	Oil & Gas Industry

Fluid Processor SoniqueFlo





SoniqueFlo Processing Mechanisms

- **Pumping**
  - Provides entrainment force for powders and liquids
  - Minimal effects on existing plant equipment
- **Heating**
  - Homogenous, cross bore, rapid heating. Very high thermal efficiency
- **Entrainment and mixing**
  - Rapid entrainment and homogenous mixing of difficult to handle powders and liquids into the process fluid
- **Separation**
  - Agitation and disruption of product
- **Volatile Stripping**
  - Stripping of volatiles in low pressure mixing zone
- **Breaking Emulsions**
  - Disruption of interfacial film, addition of heat, intimate mixing of demulsifying chemicals
- **Creating emulsions**
  - Dispersion of phases, heating, intimate mixing of emulsifiers

SoniqueFlo Test & Industrial Scale Units

Algae Processing Test Rig
Cellulac Laboratory, UK

Pretreatment Processing Full Scale Rig
Ethanol Production Plant, USA

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25 Industrial Scale, Brewing, Food, and Biochemical Installations since 2011

MillerCoors

PREMIER FOODS

greencore group

SHEPHERD NEAME MASTER BREWERS

Radeberger PILSNER

Advancing Biofuels Research NCERC AT SIUE

JUMEX

WARSTEINER FAMILIENTRADITION SEIT 1753

Bitburger

SUSQUEHANNA SBC BREWING CO

MARQUIS

tyco Fire Protection Products

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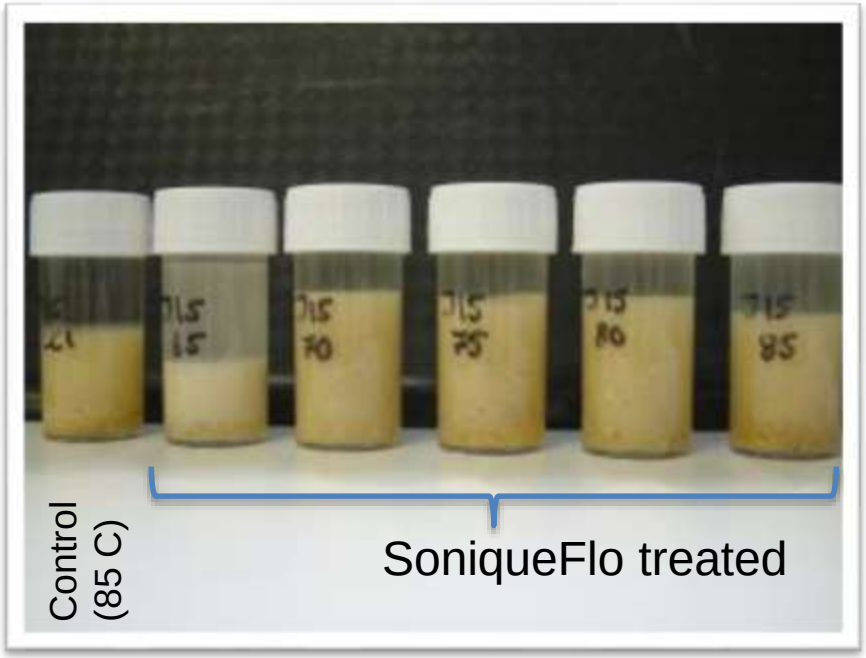
Intertek Caleb Brett

SoniqueFlo Impact on Starch

Hyper-swelling of Starch during SoniqueFlo Gelatinisation

- Increase in average swelling size of starch grains
- Provides materials Functionality
  - Increased viscosity
  - Increased and differentiated availability as an enzyme substrate



SoniqueFlo Industry Sectors/Applications

High levels of powder and liquid mixing
Rapid Performance
Homogenous & repeatable performance
Unique effects on starch
High thermal efficiency
Scalable
Controllable
No moving parts, minimal risk of blocking
Robust
Low maintenance requirements

Industry Sectors/Applications

- Food
- Beverage
- Brewing
- Bio-Energy

- Industrial Mixing
- Waste Treatment

- Oil and Gas
- Nuclear
- Paper

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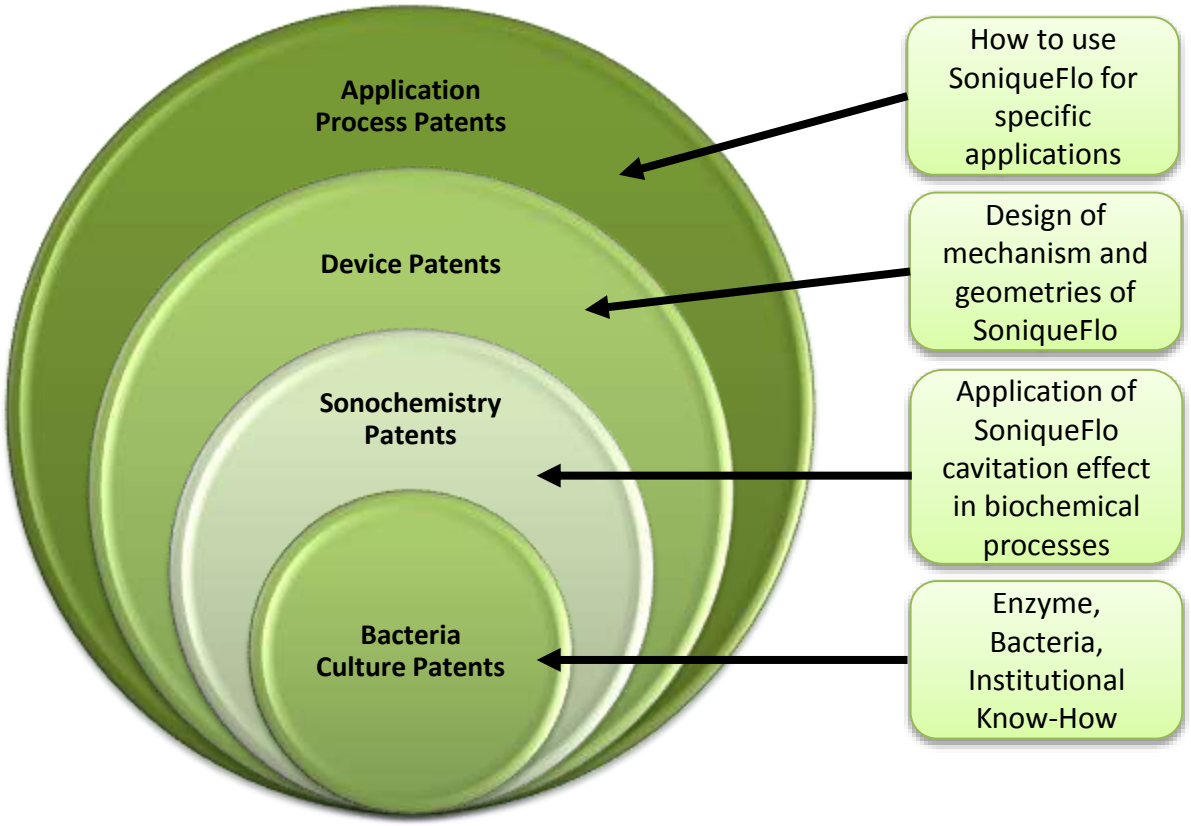
Existing 4 Layers of Protection



Cellulac Intellectual Property

- 19 families of patents and applications
  - 17 – SoniqueFlo – Fluidic hydrodynamic cavitation
    - Developed by Dr Marcus Fenton, cellulac Chief Engineer
  - 2 – Lactic Acid bacteria
    - Developed by Dr Patrick Walsh, cellulac Chief Science Officer
- 60+ granted or approved for grant patents
- 17 proprietary enzyme cell systems
- 30+ pending or provisional patents

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Agenda

1	Core Technology
2	**Food and Beverage**
3	Brewing
4	Industrial Mixing
5	BioEnergy
6	New Business Opportunities
7	Oil & Gas Industry

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Food and Beverage Installed Base

Licenced (Non Exclusively) for Food, Beverage and Brewing applications.

21 commercial food and beverage installations globally[1]

Applications areas

- Sauce and ready-meal production
- Pasta, rice and cereal cooking.
- Powder entrainment for gums and starches
- Salt and sugar dissolution

[1] As of June 2013

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Food and Beverage Process Benefits

Process Compression

- Increase capacity both in batch size and cycle time (up to 60%). Reduced physical footprint and reduced energy demand

Ingredients savings

- Physical modification (hyper-swelling) of starch in SoniqueFlo processes allows starches, flours, salt, sugar and fats to be significantly reduced in formulations whilst retaining quality sensory characteristics.

Processing of Particulates

- Processed Foods with particulates, such as pasta and diced meat and vegetables retain their integrity. Thus no back addition, reducing cost

Product Quality

- Non-contact heating eliminates product burn-on, and reduces Maillard browning giving quality appearance and flavour to products.

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Agenda

1	Core Technology
2	Food and Beverage
3	**Brewing**
4	Industrial Mixing
5	BioEnergy
6	Waste Water
7	Oil & Gas Industry

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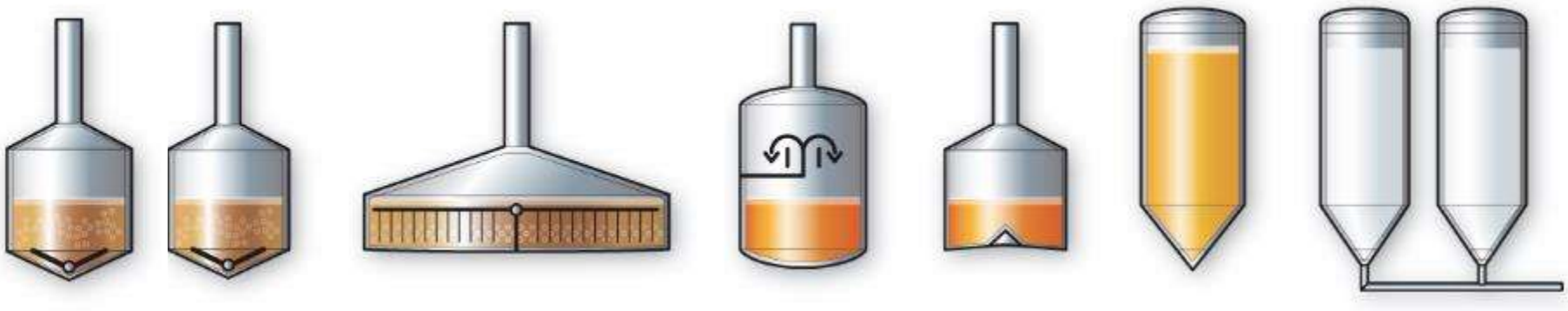
SoniqueFlo Brewing Products

Licenced (Non Exclusively) for Food, Beverage and Brewing applications.



Cereal Cooking | **Mashing** | **Lautering** | **Wort Boiling** | **Whirlpool Wort Clarification** | **Fermentation** | **Tank Disinfection**

SoniqueFlo brewing products are certified by the “Reinheitsgebot”

Brewing Wort Boiler Product

- Up to 50% energy saving
- Reduced cleaning frequency
- Automated control system
- Easily retrofits any brewery
- Boiler steam conditioning

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Installed in these breweries

Brewery	Country	Units
Shepherd Neame	England	2 x SoniqueFlo Wort
Radeberger	Germany	1 x SoniqueFlo Wort
Bitburger	Germany	1 x SoniqueFlo Wort
Warsteiner	Germany	1 x SoniqueFlo Wort
Susquehanna Brewing	United States	1 x SoniqueFlo Wort
MillerCoors	United States	1 x SoniqueFlo Wort

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Agenda

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SoniqueFlo Industrial Mixing

SoniqueFlo Types
Standard Liquid or Slurry Processing Unit
Direct Powder Entrainment Unit
Direct Liquid Entrainment Unit

SoniqueFlo Typical Uses
Heavy industrial Applications
Harsh Environments
Handling Very Coarse Slurries
Handling Very Abrasive Slurries

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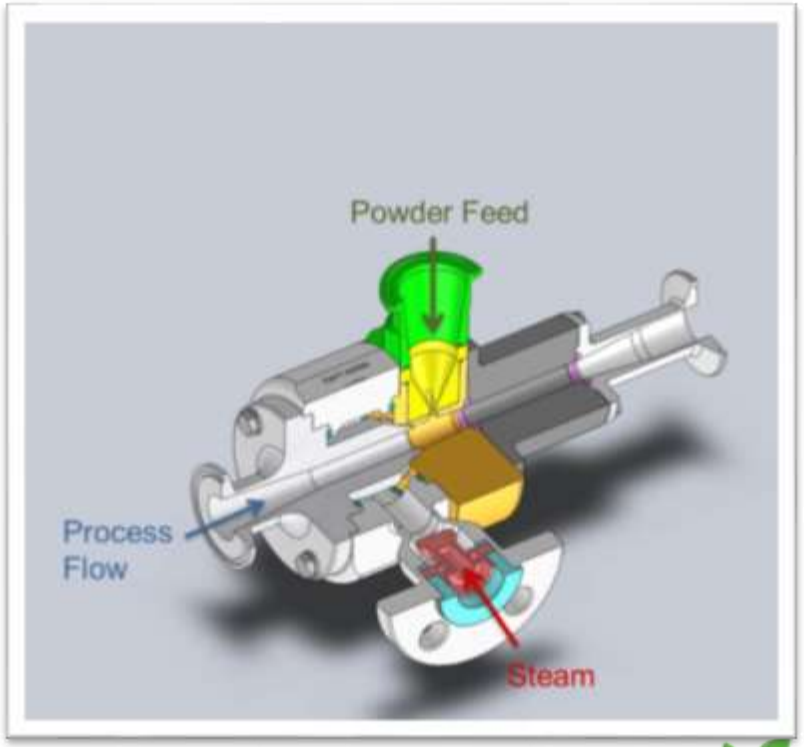
Direct Powder Entrainment Units

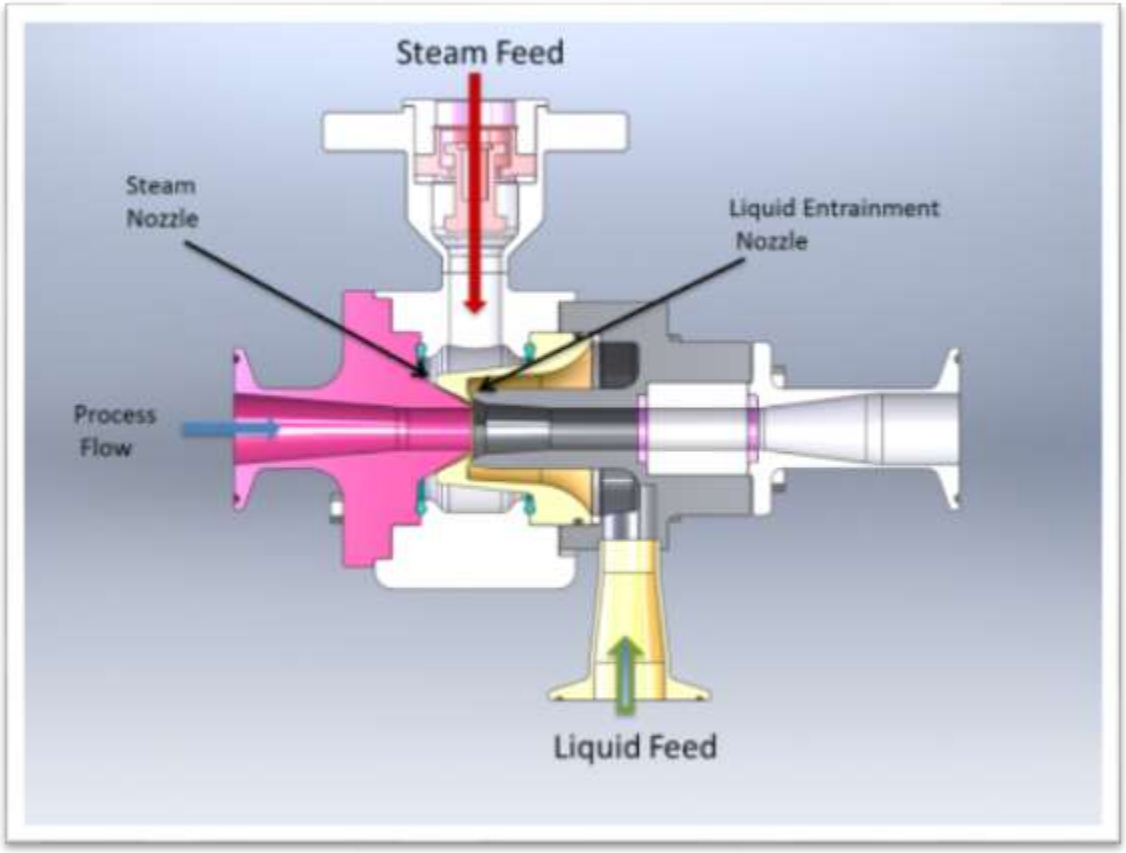
Powdered materials, such as gums, minerals, pigments and salts are entrained into the process flow via a port in the units body downstream of the steam nozzle.

Ideal for hard to handle powders (e.g. hydroscopic and hydrophobic)

- **High volume entrainment** and dispersal of inert powders (1:1 v/v)
- **Single pass** continuous entrainment of gums and binders
- **Rapid entrainment** and **hydration** of binders in low water systems (>15% w/w)
- Facilitates **dispersal** & **hydration** of powders in viscous and non-Newtonian systems



Direct Liquid Entrainment Units



A liquid is entrained into the main process flow via a second annular nozzle just downstream of the steam nozzle.

High Speed. Supersonic mixing of two fluids

High Dispersed Phase. Generates very high interfacial area for chemical reactions.

Example. Hot-Cold process for emulsion formation, new product structures.

Direct Liquid Entrainment Units

Process Type	Example System	Benefits	Industries
Hot-Cold Processes	Emulsion, dispersions, surfactant vesicles	Reduced cycle time. Reduced energy Novel new structures	Home and Personal Care Products, Paints, Coatings, Chemicals
High speed mixing	Rapid physical and chemical reaction kinetics	High product yield. Generates new processes & products	Chemicals, Materials, Ingredients, Home and Personal care
In-line process step	Conversion from batch to continuous production	Increased capacity	Chemicals

Agenda

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Gen1 - Ethanol Reactor System (ERS)

- Installed in 5 US Ethanol Plants totaling 380 MGPY
- Capacities from 45 – 130 MM gal/year
- Skid-Mounted. Fully Automated. Start-Up, Shut-Down and Clean-In-Place
- High Turbulence. Efficient heating. No Hotspots
- Reduces enzyme usage

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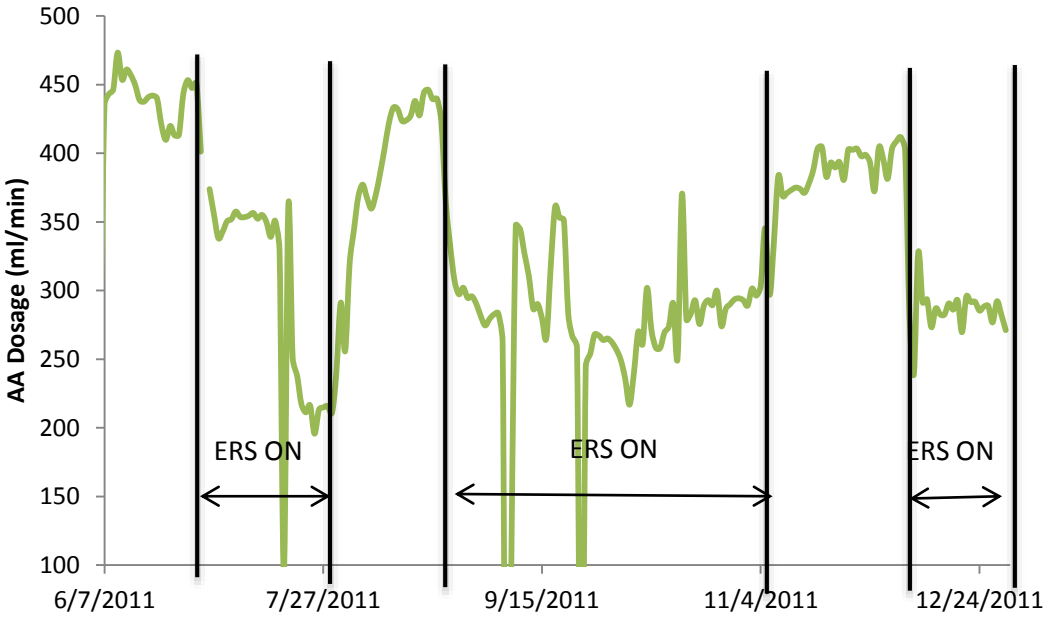
Enzyme Savings Validation

130 MM Gal/Year Plant

Consistent reduction in enzyme usage with ERS

25% reduction = ~$1,000 Per day in savings



"Also, I wanted to report that the total alpha reduction was 25%:
Normal alpha usage (4/1-4/14) is 464 mL/min
Alpha usage with liq reduction was 348 mL/min"

Amanda Marquis – Plant Chemist

Gen2 – Hemicelluloscic Materials

Trials: US sugar cane producer for cellulosic ethanol
Bagasse: by-product from sugar cane following normal sugar extraction
SoniqueFlo demonstrated the potential for enhancing the process to generate
Yield improvement
Increased efficacy
Operational efficiencies

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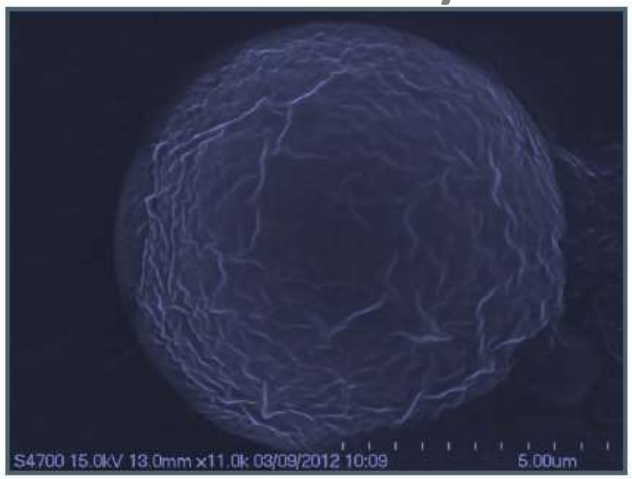
Gen3 – Algae

Library of tailored enzyme cocktails



Observations

- Algae cell wall structures are complex and poorly characterized
- Cell wall structures vary across strains & cultivation conditions
- Variety of target products are wide

Success Factors

- Enzyme cocktails tailored to a specific strain/application
- Downstream mechanical and enzyme cell disruption steps are an integral part of the lipid extraction solution

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Partners in 3rd Generation Research

€5.4m

SEVENTH FRAMEWORK PROGRAMME

€12m

fuel4me

Future European League 4 Microalgal Energy

SPLASH
Sustainable Polymers from Algae

WAGENINGEN UR
For quality of life

JOANNEUM RESEARCH

avantium

UNIVERSITY OF CAMBRIDGE

WAGENINGEN UR
For quality of life

F&M

evodos
Separation Excellence

OWS

NESTE OIL

SOLVAY

nova institute

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Agenda

1	Core Technology
2	Food and Beverage
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4	Industrial Mixing
5	BioEnergy
6	**Waste Water**
7	Oil & Gas Industry

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Waste Treatment

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Waste Treatment

Objectives

Pre-treatment of waste water sludge's to maximise the biogas yields via anaerobic digestion. Particular focus on the biodegradability of secondary sludge (SAS)

- Assessment of the pasteurisation capability of the SoniqueFlo technology

Key Findings

SoniqueFlo pre-treatment on primary sludge (PS) and secondary sludge (SAS) showed the following:

- **High solubilisation of sludge, increase in sCOD (soluble Chemical Oxygen Demand)**
  - With 3-4 SoniqueFlo passes on SAS an increase of sCOD/TS up to 800% observed
  - With 3-4 SoniqueFlo passes on Primary Sludge a gradual increase of sCOD/TS up to 300% observed
- **Decrease in *E.coli* counts after SoniqueFlo processing of waste water sludges**
  - Significant decrease (99%) in *E.coli* count with 3 SoniqueFlo passes on SAS
  - Significant decrease (99.999%) in *E.coli* count with 4 SoniqueFlo passes on PS
  - Potential for SoniqueFlo technology to be applied in pasteurisation of food waste and sludge
- **Biogas (methane) production increase**
  - 1.4 - 12.9% increase - SoniqueFlo treatment at 75^{o}C
  - 1.6 - 16.9% increase - SoniqueFlo treatment at 85^{o}C
  - 5.6 – 23.0 % increase - SoniqueFlo treatment at 95^{o}C

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Agenda

1	Core Technology
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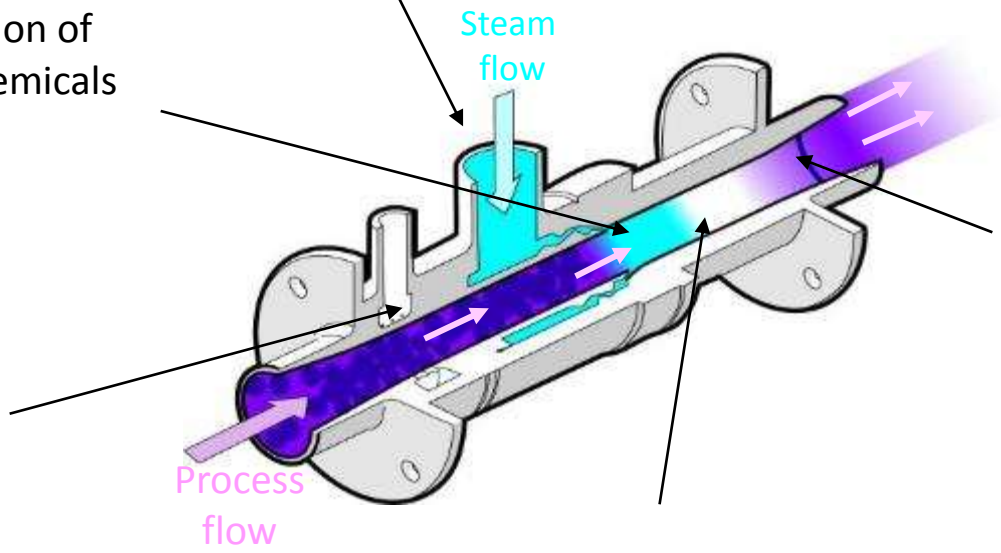
7	**Oil & Gas Industry**

Oil Industry Applications

Atomisation in the supersonic vapour phase increases surface area to maximise action of demulsifier chemicals

Addition of heat reduces viscosity and surface tension



Thermal cavitations creates high energy impact in condensation zone;
Further break-up of interfacial film and coalesces small stable water droplets

Disrupting interfacial film in the low pressure vapour zone allowing 'like-phase' coalescence

SoniqueFlo Breaking Emulsions

Enhanced mixing of demulsifier chemicals
Disrupting interfacial film allowing coalescence
Vapourising water droplets in water-in-oil mixture
Addition of air enhances flocculation effect
Releasing dissolved gas in vacuum
Addition of heat reduces viscosity and surface tension
Breaking the surfactant bonds
Disrupting electrical charge

Heavy Oil Emulsion Breaking

- **Tests run on Acidic Crude (West Africa)**
- **Extra Heavy Oil (Canadian Source)**
- Testing the SoniqueFlo against the industry standard with and without a demulsifier chemical
- **Analyses conducted:**
  - Decantation
  - Water droplet size (by Differential Scanning Calorimeter)
  - Water droplet size (by Granulometry)
  - Reference decantation curves

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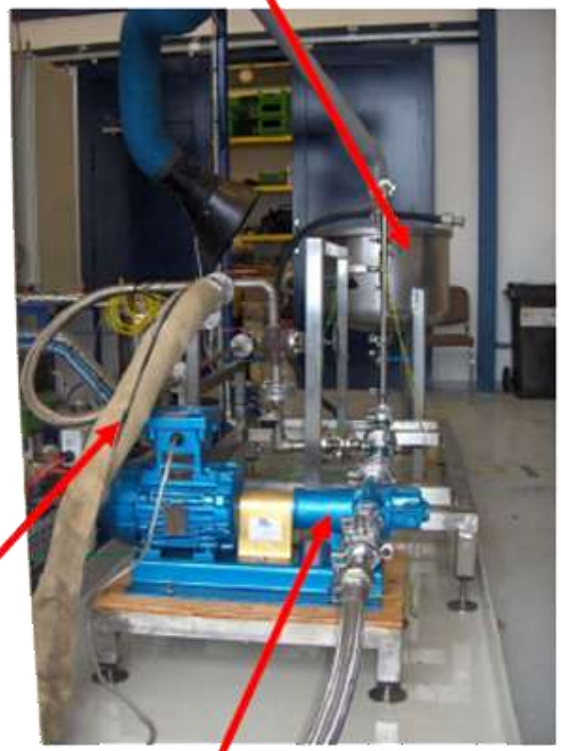
Heavy Oil Emulsion Breaking - Trials

Supply vessel

Condensate steam return line

Downstream Collection Vessel



Gear Pump

Emulsion Breaking - Results

Acidic Crude

- **Demulsification achieved** with dramatically lower demulsifier content
- Best efficiency achieved at **5** parts per million

  (as compared with the **100** parts per million standard in-field)
- Separation achieved even with **No** demulsifier

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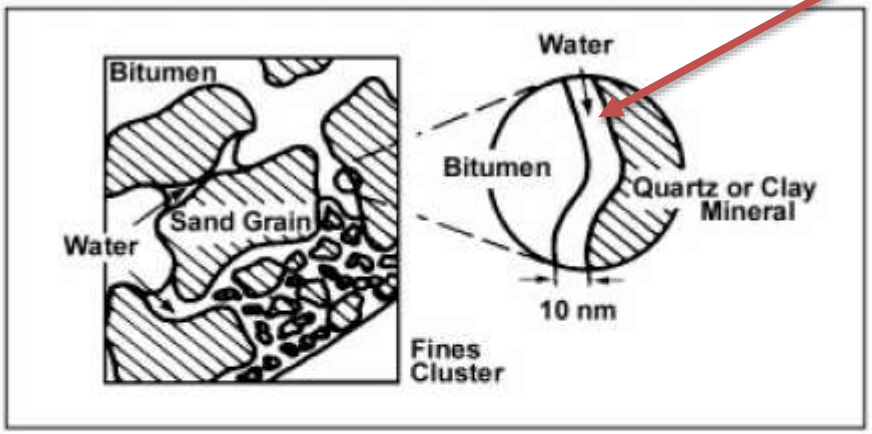
Emulsion Breaking - Results

EHO

- SoniqueFlo enhances water decantation with **No** demulsifier
- **Demulsification achieved** at **5** parts per million
  with an additional 45 ppm added afterwards

  (as compared with the >**100** parts per million standard in-field)

SoniqueFlo Impact on Oil Sands



Schematic diagram showing a structural model of Athabasca oil sand. The water in the oil sand appears in three forms: as pendular rings at grain-to-grain contact points, as a ~ 10 nm thick film which covers the sand surfaces, and as water retained in fines clusters. The remaining void is occupied by bitumen. Courtesy of AOSTRA.[b]

The 10 µm water film boils in the low-pressure zone of the SoniqueFlo and destabilizes the “emulsion” to separate quicker in the separation unit.

SoniqueFlo Impact on Oil Sands

Oil Sands separation –

- Bitumen separation of **94%** at 60 Deg. C, using non-optimised system
- Trials indicated significant capital and operating cost improvement
- No chemicals used
- Results processed at Intertek Sunbury Technology Centre

Canadian oil sands sample used in trial

Oil (%)	Solids (%)	Water (%)
11.3 %	85.3%	3.4%

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Oil Sands Separation Trials - Results

Summary of Separation Results from InterTek						
Ref No	Test Description	Slurry flow rate (kg/hr)	% of Oil in sample	% of Sand in sample	% of H20 in sample	Separation %
1	SoniqueFlo zone 1-60DegC	11800	2.96%	73.10%	21.49%	66.65%
2	SoniqueFlo zone 2 - 60DegC	10200	1.26%	79.70%	20.14%	86.66%
3	SoniqueFlo zone 3 - 60DegC	12000	0.64%	82.24%	16.32%	93.38%
4	SoniqueFlo zone 1 - 20DegC	12100	7.66%	62.40%	31.48%	6.31%
6	Baseline Sample	N/A	11.27%	85.30%	2.14%	N/A
7	SoniqueFlo zone 1 - 20DegC with Air	8100	4.87%	74.60%	18.94%	47.49%

NB. No chemicals were added in any of the tests

Extract from results:

Intertek Caleb Brett

Intertek Sunbury Technology Center

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Other Oil Industry Applications

1. Separation of water-in-oil emulsions from the SAGD process
2. Sand processing – Cleaning of sand, post separator
3. Oil fluidisation (using water or a diluent) for improved pumping/transportation
4. Drill cutting separation – breaking emulsions
5. Preparation/Mixing of drilling Muds (water and oil based)
6. Enhanced mixing of chemicals into oil or waste streams
7. H2S scavenging

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